**CHARACTERISTICS OF BACTERIA**

Review of differences between prokaryotes and eukaryotes:

|  |  |  |
| --- | --- | --- |
| **Property** | **Eukaryote** | **Prokaryote** |
| True nucleus | **Present** | **Absent** |
| DNA | **Usually many chromosomes** | **Usually single chromosome** |
| Cell division | **Mitosis** | **Binary fission** |
| Ribosomes | **Larger** | **Smaller** |
| Mitochondria | **Present** | **Absent** |
| Chloroplasts | **May be present** | **Absent** |
| Flagella | **Complex** | **Simple** |
| Size | **Usually greater than 2 μm diameter** | **Usually less than**  **2 μm diameter** |
| Microorganism examples | *Amoeba, Euglena, Paramecium* | *E. coli, Bacillus anthracis* |

Bacteria are **pro** karyotes. They can be divided into two groups, **Archaebacteria** and **eubacteria**. **Archaebacteria** are unique, because they share traits with eukaryotes and eubacteria.

Archaebacteria

Three major groups of Archaebacteria are: **thermophiles** ,

**halophiles** , and **methanogens** .

**Thermophiles** live in extremely hot environments, like hot sulphur springs. An important biotechnological enzyme comes from one of these species, *Thermus aquaticus*.

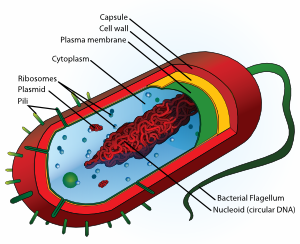
**Methanogens** live in oxygen-free environments, such as swamps, and the intestines of animals; they produce methane gas. These are important in cleaning sewage leaks, and oil spills.

**Halophiles** live in very salty conditions. Protein from these bacteria may be used in a test to detect some cancers.

Eubacteria

These can be generally broken down into one of two groups, based on characteristics of the molecules that make up the **cell** **wall** . One of these molecules is a polymer called peptidoglycan, and the presence, or absence, of this polymer is detected by the **Gram** staining method. Bacteria whose cell walls contain peptidoglycan will stain a violet colour, while those without that polymer will stain red. We call the bacteria that contain peptidoglycan, and turns violet, Gram **positive** , and those without peptidoglycan in the cell wall, and stain red, Gram **negative** .

It is difficult to apply the Gram method to Archaebacteria, because, even though the cell walls do not contain peptidoglycan, some have similar compounds that react with the staining solution, in unpredictable ways.

[](javascript:edit(29949))

Other Ways to Compare Eubacterial Species

Species can be classified according to cell shape, cell configuration, type of respiration, and type of nutrition.

The three basic cell shapes are: **spherical** (Cocci), **rod-like** (Bacilli), and **spiral**  (Spirilla).

The Cocci and Bacilli can form several configurations of cells: **single**

(Monococcus, Monobacillus), **two-cell** (Diplococcus, Diplobacillus), **chain**  (Streptococcus, Streptobacillus), **clump** (Staphylococcus only), and others.

Some bacteria, such as those causing tuberculosis, require oxygen for cellular respiration. They are described as **aerobic** . Other bacteria, such as those that cause gangrene and tetanus, only grow when no oxygen is present. They are described as **anaerobic** . Many bacteria can grow with or without oxygen. This group includes *E. coli*.

Some Eubacteria are autotrophic, performing either **photo** synthesis or **chemo** synthesis. Most Eubacteria are **hetero** trophic, feeding off of either living or dead tissues.

Reproduction in Eubacateria and Archaebacteria

Bacteria reproduce asexually by binary fission.

A form of sexual reproduction called **conjugation** exists among certain species, including *E. coli*. In this process, small, circular pieces of DNA called **plasmids** are exchanged from one bacterium to another by means of a sex pilus. These circular sequences of DNA offer to give new characteristics (e.g., antibiotic resistance) to the recipient cell.

Some bacteria are able to survive unfavourable or dangerous environmental conditions by forming a ‘sleeping’ cell, called an **endospore** . They are resistant to heat, and other extreme environments, and the cell can reactivate itself when conditions become more favourable.

Match the bacterial classification with observations that were made in the laboratory.

**C** 1. Methanogen

**E** 2. Halophile

**D** 3. Gram-negative Streptobacillus

(*E. coli*)

**B** 4. Gram-positive Staphylococcus

**A** 5. Gram-negative Anaerobic

Diplobacillus

**F** 6. Gram-positive Autotrophic

Spirilla

A) Rod-like cells stain red and form in pairs, only in absence of oxygen.

B) Cells stain violet. Cells form a clump of spherical-shaped cells.

C) Gram stain inconclusive. Dies when exposed to oxygen. Performs reaction

carbon dioxide + hydrogen gas → methane + water.

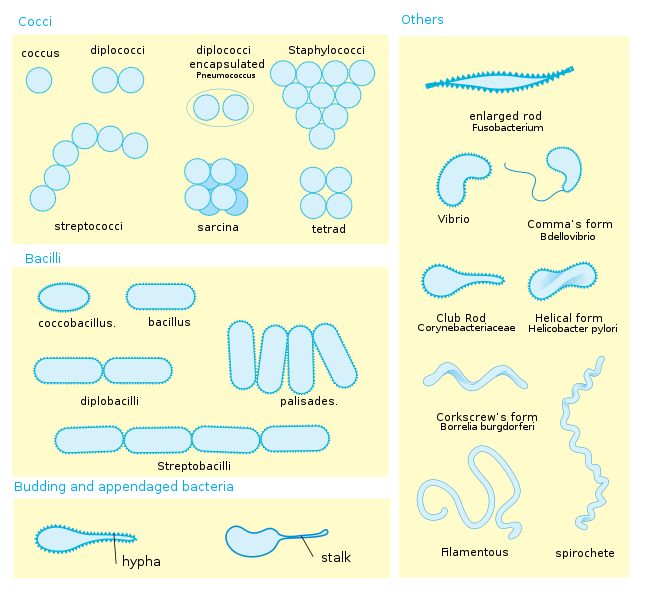
D) Cells stain red. Cells form a chain of rod-like cells. Grows in air, and in air-tight

incubation chamber.

E) Gram stain inconclusive. Grows best on high concentrations of sodium chloride, and

will not survive below an upper threshold of salt.

F) Organisms look like a corkscrew, and stain violet. Cells have a green appearance.

[](//upload.wikimedia.org/wikipedia/commons/6/69/Bacterial_morphology_diagram.svg)

**PROTISTS**

Protists have extremely diverse biological characteristics and live in diverse habitats. There are three distinct groups in the kingdom of protists. These are: **animal-like** (protozoa), **plant-like** (protophyta), and **fungi-like** .

Members of these three groups have the following in common:

Most are **uni** cellular. A few are **multi** cellular, but do not form distinct tissues.

The cells are **eu** karyotic (nucleus surrounded by **membrane** ).

The cells reproduce asexually by **binary fission** . Some exchange DNA as a form of  **sexual**  reproduction.

The cells grow well in  **wet or moist**  surroundings, such as fresh water, salt water, or animal fluids.

Plant-like Protists

These organisms perform **photosynthesis**  because they possess the green pigment  **chlorophyll** . In the dark, the cells can switch from being

autotrophic to **hetero** trophic.

Example of plant-like protists: *Euglena*. Features include: Eyespot – detects **light** . Two flagella, no cell wall, plasma membrane surrounded by firm, yet flexible, covering called a **pellicle** . Food is stored in the form of **starch granules** .

Another example of plant-like protists: **algae** (green, brown, and red). They are **multi** cellular, but do not form tissues, as opposed to higher plants.

Algae are adapted to **moist or wet**  environments. In addition to water, they can be found in soil, lower tree trunks, and on rocks.

Brown and red algae are commonly called **seaweed** , which are large, multicellular ocean plants. They contain **pigments** that let them carry out photosynthesis with the wavelengths of light available at specific depths of water. Single-celled green algae are often referred to as **phytoplankton** , near the water surface.

Algae reproduce in a variety of ways.

Algae are the main producers of energy in aquatic food chains. By their photosynthesis, they supply about 80% of the world’s **oxygen** . Too little algae, or too much, can be a big problem for aquatic ecosystems.

Algae are used by humans as a source of food, and products that come from algae are important in many industries. Algae also helped produced many deposits.

Animal-like Protists

All are **hetero** trophs. Classified according to methods of **locomotion** : pseudopods, flagella, cilia, or reliance on body fluids of host (the completely parasitic sporozoa).

|  |  |  |  |
| --- | --- | --- | --- |
| Organism | Amoeba | Paramecium | Sporozoa (e.g., Plasmodium) |
| Locomotion | Pseudopod | Cilia (arm-like for swimming) | No independent locomotion |
| Structural Features | Cytoplasm has outer layer (ectoplasm), and inner layer (endoplasm) | Trichocysts – poison tips for defence, or to capture prey  Two nuclei – macro nucleus controls cell activities, micronucleus assists in reproduction. | Fewer organelles and specialized structures than most protozoans. |
| Reproduction | Binary fission (one per day) | Binary fission; sometimes sexual by conjugation. | Asexual formation of spores in animal tissues. Spores are haploid. |
| Feeding | Phagocytosis – food digested in food vacuole. | Cilia direct food into oral groove, ultimately into gullet and food vacuole. Wastes expelled through anal pore. |  |
| Other |  | Lives in fresh, and salt water. Under bad environmental conditions, can form resting cells called “cysts”. |  |

Disease-causing animal-like protists

*Plasmodium* – a sporozoan, causes **malaria** , is spread to humans by *Anopheles* mosquitoes. The mosquito is a  **vector**  that transmits the disease from one host to another. Most effective way to prevent disease is to eliminate the vector.

*Entamoeba* – causes amoebic dysentery. Organism lives, and feeds on, the wall of the **large intestine** . Disease spreads when the amoeba forms cysts that leave the body via feces, and contaminates food and water. In countries where amoebic dysentery occurs, many humans possess the organisms without having any symptoms of illness. These people are called **carriers**  of the disease.

*Trypanosoma* – causes African sleeping sickness. It is transmitted by **the tsetse**  fly. Growing in human blood, it releases toxins that affect the **nervous** and lymphatic systems.

Fungi-like Protists

Also referred to as **slime molds** . They prefer to live in shaded, cool, and moist habitats; usually found under, or on, rotting leaves or logs.

At some times, slime moulds resemble animal-like protists, and move like amoebae, or use flagella. At other times, they produce **spores** , like fungi.

Slime moulds do not only remain as single cell organisms, the cells can converge into a large slimy mass.

**MICROORGANISMS IN ECOSYSTEMS**

Many microorganisms obtain their **nutrition**  through symbiotic relationships with other living things in their environment. There are three types of symbiotic relationships: **parasitism** , **commensalism** , and **mutualism** .

Parasitism is identified as a +/ **-**  relationship where one species benefits (the **parasite**), and the other (the **host**) is harmed. All  **disease** -causing microorganisms, including viruses, are parasites.

Example: Oral bacteria in the human mouth digest sugars and produce lactic acid that dissolves tooth enamel, causing **cavities** .

Commensalism is identified as a +/ **0**  relationship, where one species benefits, and the other is neither helped nor harmed.

Example: *Corynebacterium* lives on the surface of the human **eye** , feeding on secretions from that organ. The human is neither helped nor harmed.

Mutualism is identified as a  **+** / **+**  relationship, where both partners benefit. Species are so interconnected that, often, one’s lifecycle cannot be completed without the other.

Example: *E. coli* and human intestines produce  **vitamins**  for humans; *Rhizobium* bacteria in the root of legumes; protozoans in the gut of termites.

Agriculturalists use a process called “effective microorganisms” (EM), which is a mixture of  **lactic**  **acid bacteria** , **yeast** and **photosynthetic bacteria** . Application of these organisms improves soil structure and fertility, reduces the need for **pesticides** , and increases **productivity** . EM is also used in aquaculture, livestock production, and recycling.

Pesticides are used to control insects, diseases, weeds, and microorganisms on agricultural products. They are designed to attack particular pests without affecting **harmless/beneficial**  organisms. However, widespread use has shown that, when one species in an ecosystem is affected, so is the diversity of organisms. Any measure that reduces soil  **microorganisms**  also reduces nutrient cycling and affects plant growth.

Many Canadian cities now use integrated pest management (IPM), which is a combination of  **cultural** ,  **biological** , **genetic** , and **chemical** , to control pests in their parks, and open areas.

**SYMBIOTIC RELATIONSHIPS**

*Please place*

COMMENSALISM (C) PARASITISM (P) MUTUALISM (M)

\_ **C**\_\_\_\_ barnacle/whale Barnacles create home sites by attaching themselves to

whales. This neither harms nor benefits the whales.

\_\_**P**\_\_\_ mistletoe/spruce tree Mistletoe extracts water and nutrients from the spruce tree

to the tree’s detriment.

\_\_**M**\_\_ yucca plant/yucca moth Yucca flowers are pollinated by yucca moths. The moths

lay their eggs in the flowers where the larvae hatch and eat

some of the developing seeds. Both species benefit.

\_\_**C**\_\_ hermit crab/snail shell Hermit crabs live in shells made and then abandoned by

snails. This neither harms nor benefits the snails.

\_\_**M**\_\_\_ oxpecker/rhinoceros Oxpeckers feed on the ticks found on a rhinoceros. Both

species benefit.

\_\_**C**\_\_\_ cowbird/buffalo As buffalos walk through grass, insects become active and

are seen and eaten by cowbirds. This neither harms nor

benefits the buffalos.

\_\_**P**\_\_\_ mouse/flea ` A flea feeds on a mouse’s blood to the mouse’s detriment.

\_\_**M**\_\_\_ wrasse fish/black sea bass Wrasse fish feed on the parasites found on the black sea

bass’s body. Both species benefit.

\_\_\_**P**\_\_ deer/tick Ticks feed on deer blood to the deer’s detriment.

\_\_\_**C**\_\_ silverfish/army ants Silverfish live and hunt with army ants They share the prey.

They neither help nor harm the ants.

\_\_\_**P**\_\_ cuckoo/warbler A cuckoo may lay its eggs in a warbler’s nest. The

cuckoo’s young will displace the warbler’s young and will

be raised by the warbler.

\_\_\_**M**\_\_ honey guide bird/badger Honey guide birds alert and direct badgers to bee hives.

The badgers then expose the hives and feed on the honey

first. Then the honey guide birds eat. Both species benefit.

\_\_\_**P**\_\_ hookworms/humans Hookworms enter the human body by burrowing into the

skin of the feet. Once in the skin they enter the bloodstream

and travel to the small intestine where they attach to the

walls and begin to the drink the person’s blood and weaken

the victim.

\_\_**C**\_\_\_ kapoc trees/orchids Types of orchids grow high on the branches of the tall

kapoc trees of the jungle. This adaptation allows the orchid

to receive enough sunlight to perform its photosynthesis but

the kapoc trees are unaffected.

\_\_**M**\_\_\_ lichen algae/lichen fungus Lichens are close associations of fungi and algae. The fungi

hold the water supply and the algae perform photosynthesis

and manufacture the carbohydrates for both.

\_\_\_**M**\_\_ acacia tree/ants In the jungles of South America live a thorn tree called an

acacia. A species of ant eats secretions of the acacia, drink

its sap, and raise its young in the hollow thorns. The ants

also keep competing vines from growing near the acacia

tree and they help repel any insects that would damage the

acacia.

\_\_\_**P**\_\_ moose/tapeworm In the flesh of the moose are the cysts (dormant stage) of a

worm that makes the muscles of the moose stiff and sore. If

the moose is killed and eaten raw, the predator species will

develop a form of tapeworm.

\_\_\_**C**\_\_ lactobacilli/humans Lactobacilli are a type of bacteria that live in our lungs and

destroy many of the microorganisms that enter our

respiratory system. They are highly adapted to living in our

lungs and can’t survive in many other habitats.

\_\_\_**M**\_\_ soybeans/bacteria Soybeans require nitrogen from their environment. This

nitrogen is provided by bacteria that live in special root

nodules. In return, the bacteria receive some of the sugar

(carbohydrates) manufactured by the soybeans.

**HELPFUL AND HARMFUL BACTERIA**

Helpful Features of Bacteria

Bacteria recycle dead organic material. These organisms are referred to as **saprophytes** . Otherwise, food chains would be broken; producers would not have enough nutrients to grow, and consumers would have nothing to eat.

Bacteria are used in the process of **bioremediation** , in order to remove pollutants from the environment. For example, a bacterium from the genus *Flavobacterium* is able to use a toxic wood preservative (penta-chlorophenol) as a nutrient for its growth. It is much **cheaper**  to clean contaminated soil with *Flavobacterium* rather than burning away the contaminant. Another advantage of this strategy is that, once the contaminating chemical is used up, the bacteria die.

Many bacteria have the potential to maintain human health, and prevent disease; they are referred to as **probiotics** . These may be added to **food** , or used in the treatment of  **infections**  (ear, intestinal, urinary tract). They may, also, be used to reduce blood **cholesterol**  levels, and to actually prevent tooth decay, and some cancers.

During their metabolism, bacteria produce **enzymes**  that are helpful to many people. It is usually less expensive to use intact bacteria than enzymes isolated and prepared from these organisms.

Harmful Bacteria Case Studies – Walkerton, Ontario

Bacteria cause a variety of diseases, including Anthrax, Legionnaires ’ disease, Diphtheria, Typhoid Fever, Bubonic Plague, Tuberculosis, etc.

In May of 2000, bacteria from the **feces**  of cattle were washed into the well water of Walkerton, Ontario. Symptoms of illness included: vomiting, cramps, bloody diarrhea, and fever. The drinking water was contaminated with the *E. coli* strain O157:H7.

The combination of numbers and letters in the name O157:H7 refer to specific markers found on the **surface**  of the bacterium. This strain produces a toxin that the immune system of a healthy adult can fight in five to ten days, without special **antibiotics** . The toxin can kill young children and the elderly; effects include: destruction of red blood cells, kidney failure, seizures, or strokes.

The main source of O157:H7 is undercooked **ground beef** , which can be contaminated with feces as the meat is being processed. Other sources of this strain include: processed meat, sprouts, leafy green produce, unpasteurized milk and juice, and contact with cattle. Also, it can be spread by swimming in **contaminated**  **lakes** , or drinking **inadequately chlorinated**  water. The bacterium is easily transmitted from  **person**  to **person** .

Proper **chlorination** of the water may have been able to save the lives of seven people who died in Walkerton. Ultraviolet (UV) light can also be used to  **purify**  the water.

Bacteria cause illness in a variety of ways. In Walkerton, toxins overloaded the body’s **immune**  system. In some cases, the sheer number of invading bacteria place high stress on the host’s normal tissues. Some bacteria destroy cells and tissues.

Helpful Bacteria – Table

|  |  |
| --- | --- |
| **Type of Bacteria** | **Beneficial Effect** |
| *Clostridium* | Produces butanol and acetone from molasses |
| *Acetobacter* | Produces vinegar from ethanol |
| Intestinal bacteria | Food digestion; synthesis of vitamins for humans |
| *Lactobacillus* | Produces lactic acid from sugar; prevents growth of harmful bacteria in dairy products |
| *Azotobacter, Nitrobacter* | Nitrogen fixing in soil |
| *Streptococcus* | Production of dairy products |
| *Streptomyces* | Soil bacteria; source of antibiotics |
| *Pseudomonas* | Clean up of waste in sewage treatment |
| *Bacillus* | Soil bacteria, natural pest killer |

Harmful Bacteria – Table

|  |  |
| --- | --- |
| **Type of Bacteria** | **Disease/Destruction Produced** |
| *Clostridium* | Botulism, tetanus, gangrene |
| *Streptococcus* | Strep throat, scarlet fever, pneumonia |
| *Staphylococcus* | Boils; food spoilage; food poisoning; skin, blood, and eye infections; pneumonia |
| *Lactobacillus* | Souring of milk |
| *Pseudomonas* | Gasoline spoilage; food spoilage; blood infections; eye infections |
| *Bacillus* | Destruction of silk worms, tuberculosis, anthrax |
| Coliform bacteria | Pollution of water sources, soft rot in plants, gastroenteritis, dysentery |
| *Spirillum* | Syphilis |